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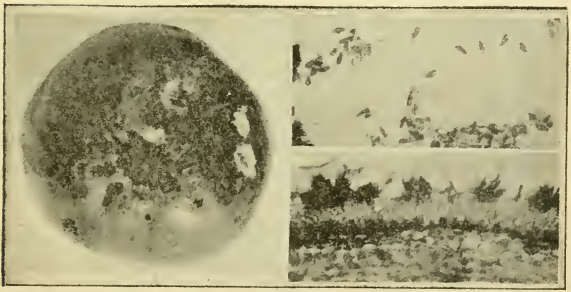
NEW HAMPSHIRE COLLEGE

AGRICULTURAL EXPERIMENT STATION

SPRAYING EXPERIMENTS IN 1894

BY H. H. LAMSON



NEW HAMPSHIRE COLLEGE

OF

AGRICULTURE AND THE MECHANIC ARTS

DURHAM, N. H.

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OF

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AGRICULTURAL EXPERIMENT STATION

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SPRAYING EXPERIMENTS IN 1894

BY H. H. LAMSON

The experiments recorded in this bulletin are a continuation of similar ones carried on in 1892 and '93, directed chiefly to the treatment of the fungous diseases of the apple, pear, and potato.

Numerous varieties of apples and pears are affected with the disease known as the *scab*, which is caused by the growth of a minute parasitic or fungous plant. Frequently very serious injury is done, both to the foliage and fruit, and some varieties are almost a complete failure on account of it. The scab grows on the surface of the leaves and fruit. On the leaves it grows in dark green or smoky spots and patches, frequently causing them to become much wrinkled; on the fruit the scab produces characteristic dark green or black spots, rounded in outline with sharply defined margins. When attacked early, the fruit is liable to be one-sided, and in many cases it is badly cracked.

PEARS

About two-thirds of a Flemish Beauty pear tree was sprayed and the other third left unsprayed. The spraying was done on April 30, May 22, June 15 and 30. 1 to 12 Bordeaux mixture (1 pound blue vitriol to 12 gallons of water; see under heading Bordeaux mixture) was used. The pears, when gathered, showed the following result:

	Unsprayed.	Sprayed.
1st quality,	23 per cent.	70 per cent.
2d "	67 "	30 "
3d "	10 "	

An increase of 47 per cent, apparently due to spraying.

The third quality in this and the following tables of results of pear experiments means fruit cracked as well as scabby.

A Louise Bonne pear tree was sprayed with 1 to 12 Bordeaux mixture on April 30, May 22, and June 15 and 30. Another tree of the same variety was left unsprayed for comparison. The pears, when gathered, showed the following result:

	Unsprayed.	Sprayed.
1st quality,	4 per cent.	20 per cent.
2d "	93 "	80 "
3d "	3 "	

An increase of 16 per cent of first quality fruit. Very many of the pears were classed as second quality on account of their small size. The following table shows the percentages of scabby pears on the two trees:

	Unsprayed.	Sprayed.
Pears free from scab,	58 per cent.	98 per cent.
" more or less scabbed,	42 "	2 "

Giving an increase of 40 per cent of pears free from scab on the sprayed tree.

Five Lawrence pear trees were made the subjects of another experiment. Three were sprayed with 1 to 12 Bordeaux mixture and two were left unsprayed. The spraying was done on May 2, June 9 and 26, and July 26. The pears, when gathered, showed the following result:

	Unsprayed.	Sprayed.
1st quality,	50 per cent.	67 per cent.
2d "	50 "	33 "

Giving an increase of 17 per cent of first quality pears on the sprayed trees.

These pears were affected with two different species of fungus, the *scab*, and what, for want of a better name, we have called the "*moth patch*." The latter gives the fruit a dirty, smoked appearance, occurring sometimes in roundish blotches, but frequently almost entirely covering the fruit. This disease also affects some varieties of apples, e. g., the Greening and

the Northern Spy. It is readily distinguished from the scab, which usually occurs in darker, thicker, and more sharply defined spots. The following table shows the percentages of scab and moth patch on the sprayed and unsprayed trees:

	Unsprayed.	Sprayed.
Scab,	36.1 per cent.	3.5 per cent.
Moth patch,	98.9 "	1.3 "

Giving a decrease of 33 per cent of scab and 97 per cent of moth patch on the sprayed trees.

APPLES

About forty Baldwin apple trees in the orchards of the college farm were sprayed with Bordeaux mixture. The apples from these trees and from unsprayed ones for comparison were gathered and stored in the barn which was burned Nov. 3, '94. The apples were all destroyed. The apples from five trees only had been sorted. Of these trees, two were sprayed and three unsprayed. The two trees were sprayed four times with 1 to 12 Bordeaux mixture, viz., on April 28, May 23, June 13 and 30. On May 23 and June 13, six ounces of Paris green per fifty gallons was added to the Bordeaux mixture for the codling moth. The following table shows the result:

	Unsprayed.	Sprayed.
1st quality,	58 per cent.	79 per cent.
2d "	23 "	14 "
3d "	19 "	7 "

Giving an increase of first quality in favor of sprayed trees of 21 per cent.

The percentages of scabby and wormy fruit were:

	Unsprayed.	Sprayed.
More or less scabby,	33 per cent.	3 per cent.
Wormy,	17 "	6 "

In the orchard of Mr. DeMeritt twenty-four Baldwin apple trees were sprayed with 1 to 12 Bordeaux mixture. The first spraying was done May 2, just as the leaf buds were beginning to

open. June 9, just after the blossoms had fallen, the trees were sprayed again. At this spraying six ounces of Paris green per fifty gallons was added to the Bordeaux mixture for the codling moth. This spraying did considerable injury to the foliage, so that only half of the trees were sprayed a third time on June 26, Bordeaux mixture alone being used at this time.

When the apples were gathered, the fruit from eight of the sprayed trees was saved for examination, and also the fruit from eight unsprayed for comparison. Four of the sprayed trees received three applications and four only two, but owing to lack of time and conveniences, the apples were not kept separate, so that the apples from the eight trees as a whole may be said to have received two and one-half sprayings. The following table shows the result:

	Unsprayed.	Sprayed.
1st quality,	20 per cent.	36 per cent.
2d "	58 "	42 "
3d "	22 "	22 "

Giving an increase of 16 per cent of first quality fruit in favor of the sprayed trees.

The percentages of scabby and wormy fruit were:

	Unsprayed.	Sprayed.
Scabby,	79 per cent.	19 per cent.
Wormy,	20 "	8 "

The windfalls which were under the trees were picked up before the fruit on the trees was gathered, and were sorted and counted. The following shows the percentage of windfalls to the total number of apples on and under trees:

	Unsprayed.	Sprayed.
Windfalls.	35 per cent.	23 per cent.

The windfalls showed:

	Unsprayed.	Sprayed.
Scabby,	50 per cent.	9 per cent.
Wormy,	59 "	32 "

Aside from the scab, much of the unsprayed fruit was affected

by another fungous disease, which made its appearance in the form of dark brown spots varying in size from mere dots to spots one-sixteenth inch or more in diameter. The spots were usually slightly depressed or sunken below the general surface. The presence of this disease made it necessary to class many apples of good size and shape as seconds. The sprayed apples were almost entirely free from this trouble. Our observation indicates that the diseased spots tend to grow larger on the stored fruit and to serve as the starting points of decay.

In case of nearly all of the sprayed trees more or less injury was done to the foliage by the second spraying, when Paris green was added to the Bordeaux mixture. The usual amount of Paris green recommended is four ounces to a barrel, or fifty gallons. In this case six ounces were used. It was thought, however, that the lime in the Bordeaux mixture would prevent any bad results, and we are at a loss to account fully for the injury done. It may perhaps be partly accounted for by the fact that where the worst damage occurred the spraying was done on a bright, hot day—a condition which is known to favor the injurious tendencies of Paris green.

Lichens or Moss.—Many fruit trees are covered with different varieties of lichens or "moss," as they are often called. It is a question not yet decided how much direct injury they do to the trees, but they are unsightly and offer protection to insects and their eggs. The Bordeaux mixture is very effective in destroying them.

Russety Fruit.—Among our sprayed apples we found some with a rough or russety skin, and thought at first that it was due to spraying, but we found that many unsprayed ones were just as bad. In fact many apples last season showed this russeting. The late frosts last spring, just as the trees were in bloom, were perhaps to blame for this. It must be noted, however, that the Bordeaux mixture does sometimes produce a similar effect. We also heard of numerous instances last fall of Flemish Beauty pear trees which had not been sprayed, but which produced a fair crop of pears; something unusual for this

part of the country. The pears were also unusually russety. It seems possible that the russety surface due perhaps to frost presented an unfavorable condition for the development of the scab fungus, and thus in a measure protected the fruit from its injuries.

POTATOES

In the case of potatoes the experiments were directed chiefly towards the prevention of the *Early Blight* and the *Scab*.

The following description of the early blight is reprinted from the New Hampshire College Experiment Station Bulletin No. 22.

EARLY BLIGHT

The early blight (*Macrosporium solani*) has come to be recognized as a serious disease of the potato only within the last two or three years. It was first noticed at this station in the summer of 1892. As its name indicates, it makes its appearance earlier than the ordinary blight—by the middle of July or earlier. It first appears, as sharply defined, rather irregular, dark brown or blackish spots on the leaves. The surface of the spots is usually marked with minute wrinkles, which take roughly the form of numerous circles with a common centre; this has been called the "target marking," from its resemblance to the concentric rings of a target. The spots increase gradually in number and size till the whole leaf is destroyed.

The fungus producing this disease differs considerably in the details of its structure from the late blight, but like it, consists of mycelial threads which grow in the tissues of the leaf and send out spore-bearing stalks on the surface. The early blight may be distinguished from the late blight by its characteristic spots, by the absence of the mould-like growth on the under side of the leaf in the case of the latter, by its earlier appearance and slower growth, and by the fact that it does not affect the tubers.

The experiments against the early blight were made in the Station potato field. On July 7, plots aggregating one and one-sixth acres were sprayed with Bordeaux mixture. Alternate plots aggregating four-fifths of an acre were left unsprayed

for comparison. The spraying was repeated July 26, August 8, 21, and September 4.

The early blight did not make its appearance in the field until about the time of the third spraying, August 8, and did not begin to seriously affect the unsprayed vines until two weeks later. By the middle of September, however, the unsprayed vines were dead, while the sprayed vines, in varying proportions in different parts of the field, were alive the first of October when the potatoes were dug.

Owing to the uneven character of the field and the effects of the drouth, the yield of the sprayed plots as a whole could not be compared with that of the unsprayed plots. Smaller plots of each, as similar in character as possible, were chosen and and the yields compared. Five pairs of plots were selected, each consisting of a sprayed and an unsprayed plot of equal size lying side by side. The sprayed plots showed an increase in yield over the unsprayed as follows:

Pair No.	1	an increase of	29.1	bushels	per acre.
"	2	"	31.9	"	"
"	3	"	54.7	"	"
"	4	"	28.4	"	"
"	5	"	21.3	"	"

The average increase per acre apparently due to spraying was 33 bushels.

The cost per acre of each spraying was $3.52; for the five sprayings, $17.60. The potatoes were sold for 60 cents per bushel. At this price the 33 bushels were worth $19.80. Deducting the cost of spraying, $17.60, there was left a profit of $2.20. This, as it stands, would not be a very brilliant result, but there are several circumstances which should be taken into consideration along with it. It seems probable that three sprayings, beginning the first of August, would have answered as well as the five, beginning the seventh of July. Spraying was begun at this early date to make sure of getting ahead of the blight, which, however, did not appear till about the middle of August. Had three sprayings only been made, the cost would have been $10.56 and the profit $9.24 per acre. It is probable that owing to the drouth and the late appearance of the blight,

the difference in yield between the sprayed and unsprayed potatoes was not as great as it would be ordinarily. Again, it is possible that with the desire to make the treatment thorough, more materials were used and more time taken than was actually necessary. At each spraying 150 gallons of Bordeaux mixture per acre were used. The mixture was made according to the following formula:

Blue Vitriol.... 5 lbs.
Lime (Fresh)... 5 lbs.
Water.....50 gallons.

The blue vitriol cost, in 25 pound lots in Boston, 6 cents per pound, and about 6½ cents laid down. The lime was purchased in small quantities, and cost 1 cent per pound.

At these prices 150 gallons of Bordeaux mixture cost $1.12½, or about ¾ of a cent per gallon. In spraying an acre, two men were employed eight hours at 15 cents per hour; the time expense was $2.40. The actual time of spraying was six hours; two hours were occupied in obtaining water, making the mixture, etc.

It is probable that the expense for labor can be considerably reduced. The total expense will vary with the luxuriance of the vines, the number of applications required, the local cost of materials, the form of apparatus used, and the convenience of water. It is our belief, however, that spraying against the early blight will be found to be a profitable operation.

Late Blight of the Potato.—The late blight, or the *rust* or *rot*, as it is often called, makes its appearance usually about the first of August. It is characterized by the rapid withering and dying of the leaves, and by the appearance on the under side of the affected leaves of a fine white mold-like growth, which consists of the spores and spore stalks of the fungus producing the disease. The tubers are usually more or less affected. If the weather is warm and wet, the course of the disease is very rapid.

The early and the late blight are often present together.

POTATO SCAB.

Within a few years it has been found that this serious disease

is not caused, as has been supposed, by any condition of soil or fertilizers, but by minute parasitic plants belonging to the class known as bacteria. These little plants grow in the superficial portions of the tuber, where they act as an irritant, causing a growth of the tissues, which results in the production of the characteristic scab spots. A scabby crop of potatoes results either from the use of scabby seed, or from planting on ground which has previously produced a scabby crop. The germs of the disease live on the harvested potatoes, and also for an indefinite time in infected soil. When it was found that the scab was caused by bacteria, it readily occurred to experimenters that corrosive sublimate, a substance extensively used for the destruction of other bacterial germs, might prove useful in treating it. This has been tried, and the corrosive sublimate found to be capable of destroying the germs on scabby seed, so that when the latter was planted on soil itself free from the germs, a smooth crop was produced.

An experiment in this line was tried here last summer. Potatoes of the Deleware variety, very badly scabbed, were used. Previous to planting, half of the potatoes were treated with corrosive sublimate in the following way: Two and one-fourth ($2\frac{1}{4}$) ounces of corrosive sublimate were dissolved in two or three gallons of hot water. This was poured into a half barrel and sufficient cold water added to make fifteen gallons in all. The potatoes contained in a coarse "feed" sack were placed in this solution and allowed to remain for an hour and a half. The sack of potatoes was then taken out and after draining the potatoes were emptied out and allowed to dry. They were then cut and planted. Treated and untreated seed were planted side by side in alternate plots of two rows each, on land which had not been plowed for many years and was therefore presumably free from scab germs. When the plots were dug the tubers of marketable size were sorted into three grades, viz.: the first, practically free from scab; second, more or less scabbed; third, badly scabbed. The following table shows the results:

	Treated.	Untreated.
1st grade,	60 per cent.	31 per cent.
2d "	31 "	36 "
3d "	9 "	33 "

This shows that although the scab on the treated plots was not wholly prevented, it was greatly reduced. The seed which was very badly scabbed was not washed previous to treating it, and possibly the solution of corrosive sublimate did not penetrate to all parts of the scabby patches.

It would not be advisable, of course, to plant scabby seed even with this treatment, if clean seed could readily be obtained; but it is difficult to obtain seed in regard to which one can be certain that it is not more or less contaminated, for small patches of scab are easily overlooked. Tubers absolutely free from scab themselves, if selected from a bin in which there are a few scabby ones, would be liable to carry germs in the dirt adhering to them. In using such seed it would doubtless be beneficial to wash thoroughly in water alone, but better in the corrosive sublimate solution. The relation of fertilizers and conditions of soil to the development of scab has not yet been definitely made out, aside from the fact that they are not the direct cause of it. It seems likely that certain conditions of soil, existing naturally or produced by the use of certain fertilizers, are especially favorable to the growth of the scab plant when its germs happen to be present on the seed or in the soil.

The cost of treating the seed for an acre ought not to exceed $1.50 for both labor and materials. In the above experiment there was a gain of thirty bushels of marketable potatoes per acre on the treated plots.

As corrosive sublimate is a powerful poison, it should not be used carelessly.

BORDEAUX MIXTURE

The Bordeaux mixture is coming to be recognized as the most efficient among the many fungicides which have been tried during the past few years.

The ingredients of it are copper sulphate, which is commonly known as blue vitriol, or blue stone, lime and water. A large number of formulas, differing in the proportion of these ingredients, have been published.

The original formula, as published in this country, was Blue Vitriol, 6 pounds; Lime, 4 pounds; and Water, 22 gallons.

This has been found to be much stronger than necessary for effective work, and various degrees of dilution have been recommended. The formulas for the dilute Bordeaux mixture have been almost as numerous as the individual experimenters. While many of them have been practically identical in strength, the different wording and arrangement of proportions have been confusing, so that the movement on foot among experimenters for a simplification of formulas seems wise.

We think the method of expressing the strength of the mixture suggested in N. Y. Agricultural Experiment Station Bulletin No. 84, page 3, a good one. It is the first publication of the method which we have seen, but we have personally used it in our notes and computations for the last two years. This is, in substance, to make some weight of the blue vitriol the unit of the formulas, and to express the strength by the proportion of water used with it, *it being understood that a sufficient quantity of lime* is to be used. The pound naturally suggests itself as the unit of weight for the blue vitriol, and the gallon for the unit of water.

According to this mode of expression the original formula quoted above, viz., 6 pounds of blue vitriol to 22 gallons of water would be 1 to $3\frac{2}{3}$; 1 to 8 Bordeaux mixture would be 1 pound of blue vitriol to 8 gallons of water; 1 to 12 Bordeaux mixture would be 1 pound of blue vitriol to 12 gallons of water. By using this method it is very easy to compute the amount of materials necessary for any given quantity of the mixture.

The important ingredient of the Bordeaux mixture is the copper sulphate, or blue vitriol. This alone, dissolved in water, would be an efficient fungicide; but it would so seriously injure the foliage of plants, that the remedy would be worse than the disease. The object of the lime in the Bordeaux mixture is to prevent this injury. This it does, when used in a sufficient quantity, by producing a chemical change in the solution of blue vitriol which renders it harmless. The lime is also of use in causing the mixture to adhere more strongly to the sprayed foliage, so that it is not quickly washed off by rains.

As indicated by the original formula given above, two-thirds of a pound of lime has been found to be sufficient to neutralize a pound of blue vitriol. For convenience we have used and recommended equal weights of blue vitriol and lime. We do not know of any bad results from using this amount of lime.

Instead of weighing the lime a test has been in use during the past year or two which indicates when sufficient lime has been used. This test consists in adding a few drops of a solution of yellow prussiate of potash, or potassium ferrocyanide, as it is known chemically, to the Bordeaux mixture, when a brownish color will appear if too little lime has been used. More lime must then be added until the brown color fails to appear on adding a fresh quantity of the ferrocyanide solution. This test, when rightly used, is probably reliable. Instances are however reported of the Bordeaux mixture causing injury to foliage and fruit where this test has been used, probably from the fact that not quite enough lime had been used. It is therefore recommended that after the addition of the ferrocyanide solution ceases to produce the brown color, a still further quantity of lime should be added for safety, for a small excess is far better than a slight deficiency. Perhaps, under the circumstances, it would be safer to continue to weigh the lime, using two-thirds as much as of blue vitriol.

Perfectly fresh lime should be used. Air-slaked lime will not answer. It is therefore better to use only the lumps. Care should be exercised in slaking the lime. Water should be added only just fast enough to keep the lime wet. It should be kept thoroughly stirred after it begins to slake, as when any considerable quantity is used the bottom portions are apt to become dry and "burnt." After the lime is slaked, sufficient water should be added to make it of the consistency of fresh cream. It is then ready to be added to the solution of blue vitriol. The blue vitriol may be dissolved quickly in hot water, or the required amount may be placed in a basket or loosely woven sack and suspended in a tub or other wooden vessel of cold water. As fast as it is dissolved the solution, which is heavier than the water alone, will sink to the bottom of the vessel and a fresh portion of water will come in contact with the crystals

until they are completely dissolved. About two quarts of cold water are required to dissolve a pound of blue vitriol. This is a good way of dissolving the blue vitriol when it is not wanted for immediate use, and is preferable to putting the crystals loose in the bottom of the vessel, for in that case they will dissolve very slowly unless kept constantly stirred.

Our actual practice has been to make a stock solution, by dissolving the blue vitriol in a sufficient quantity of hot water and then adding enough cold water to make half as many gallons as there were pounds of blue vitriol. Two quarts of this stock solution therefore represents one pound of blue vitriol. This is a very convenient way, especially where small quantities only of Bordeaux mixture are used at a time. A stock solution of lime also may be made. These stock solutions should be carefully protected from evaporation.

The slaked lime should be strained before adding to the solution of blue vitriol; or better still, perhaps, the completed Bordeaux mixture should be strained before pouring into the pump tank, in order to remove the coarser particles, which would be liable to clog the spraying nozzle. The straining may be done through coarse sacking, or a wire strainer with a mesh about one-sixteenth of an inch wide.

The Bordeaux mixture should be kept thoroughly stirred up during the time of spraying. It is at its best for only a few hours after its preparation; it soon develops a greater tendency to settle and loses a part of its valuable property of sticking to the foliage. We would recommend as a formula for Bordeaux mixture for general use:

Blue Vitriol,	1 pound.
Lime, fresh,	2 "
Water,	10 gallons.

This makes a 1 to 10 mixture. To make a combined insecticide and fungicide, Paris green or London purple may be added to the Bordeaux mixture, in the proportion of four ounces ($\frac{1}{4}$ pound) to fifty gallons. This combination is useful in the spraying of apple trees just after the blossoms fall, as it serves to destroy both the scab and the codling moth. A second spraying with it ten days or two weeks later is also advisable.

The combination may also be used for potato blight and bugs.

Paris green may be used with water in the proportion of four ounces to fifty gallons. A pound of fresh lime, or an equivalent quantity of slaked (not air-slaked) lime added to it, will lessen the danger of injury to foliage from its use. This answers for canker worm.

One of the most important points to be observed in the use of mixtures containing Paris green, is to keep them *thoroughly stirred up.*

RECOMMENDATIONS

Pear and Apple Scab.—Spray with Bordeaux mixture once before the blossoms open; again just after they have fallen, and then a third time after ten days or two weeks. Rainy weather may make a shorter interval and an additional spraying advisable.

At the second and third sprayings Paris green or London purple, in the proportion of four ounces to fifty gallons, may be added to the Bordeaux mixture for the codling moth.

Potato Blight.—For the early blight spraying with Bordeaux mixture should be begun by the middle of July, or sooner if the characteristic brown spots of the disease make their appearance. The spraying should be repeated twice, with an interval of ten days or a fortnight. If the weather is rainy, the interval between sprayings should be shortened and a fourth application may be advisable. This treatment will serve for both the early and the late blight. If it were known that only the late blight was to be dealt with, the spraying might usually be delayed till the last of July.

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